Monolithically integrated InGaAs microdisks on Si for nanophotonics

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Abbreviated abstract: Template-assisted selective epitaxy enables the local integration of group III-V semiconductors on Si with high material quality for nanophotonic applications. Here we demonstrate evidence of room temperature lasing at 1530 nm for a monolithically integrated InGaAs whispering gallery mode cavity on Si with a thickness of 300 nm and a diameter of 1.5 µm. These devices can potentially be scaled down further by cladding them with metal.

Related work

1. P. Tiwari, et al., CLEO Europe 2021, CK4.2 (to be presented on 24 June 2021)
2. P. Tiwari et al., Optics Express 29(3), 2021

Acknowledgments

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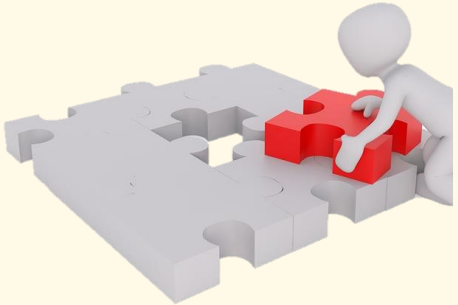
Monolithic integration of III-Vs on Si

Silicon

Established technology platform

Indirect bandgap (inefficient for light sources)



III-V Semiconductors

Direct bandgap

High carrier mobility

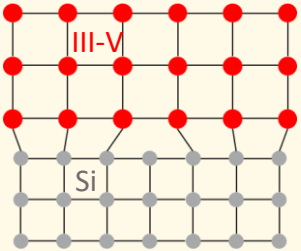
High absorption coefficient

Challenge

Lattice mismatch to Si of GaAs 4% - InSb 19%

Large polarity and thermal expansion coefficient mismatch

→ **defects**



Approaches to integrate III-Vs on Si for photonics

Wafer bonding 🕮 G. Crosnier et al., Nature Photonics 11(5), 2017

Planar epitaxy 🕮 Y. Wan et al., Optica 4(8), 2017

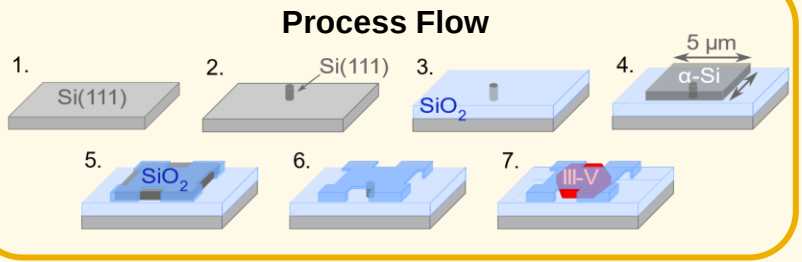
Aspect ratio trapping 🕮 Y. Han et al., Optica 7(2), 2020,

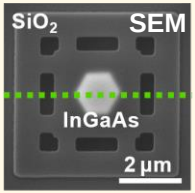
Nanowire growth 🕮 H. Kim et al., Nano Letters 17(6), 2017

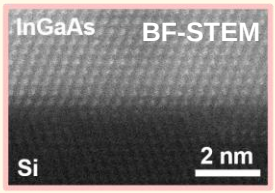
Solution for local integration

Dislocation-free integration on Si by **template-assisted selective epitaxy (TASE)**

InGaAs whispering gallery mode cavity emitting at 1530 nm



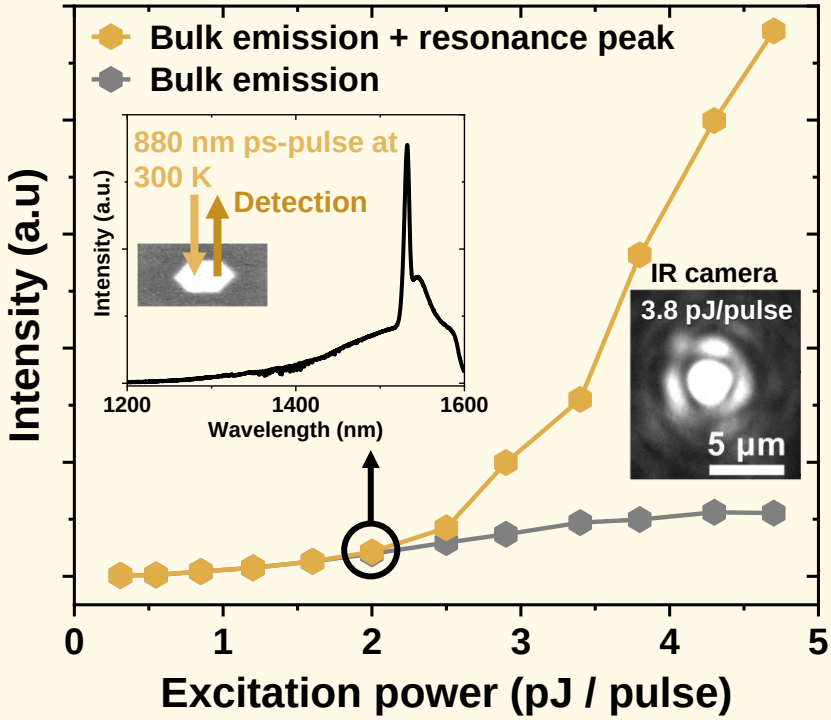




→ MOCVD growth of III-Vs into hollow oxide template after nucleation at Si seed

→ Confined Si seed prevents propagation of defects and dislocations

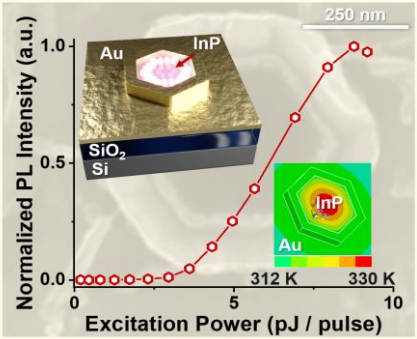
→ **Evidence of room temperature lasing at 1530 nm**



Conclusion and Outlook

→ Demonstration of local monolithically integrated high-quality ternary III-Vs on Si with evidence of lasing in the telecom band

→ Potential for improved heat sinking and down scaling cavity dimensions with metal cladding (demonstrated for bonded devices)



📖 P. Tiwari et al., Optics Express 29(3), 2021

→ **Next: Exploring metal cladding on TASE grown cavities for nanolasers**

TASE and wafer bonding for microdisk cavities
→ **P. Tiwari, et al., CLEO Europe 2021, CK4.2**
(to be presented on 24 June 2021)
→ **P. Tiwari et al., Optics Express 29(3), 2021**
→ S. Mauthe et al., JSTQE 25(6), 2019

TASE for photodetection
→ **P. Tiwari, et al., OFC 2021, F2C.2**
(to be presented on 10 June 2021)
→ S. Mauthe, et al., Nat. Comms. 11, 2020

TASE for photonic crystal cavities
→ **M. Scherrer, et al., CLEO Europe 2021, CK7.3**
(to be presented on 25 June 2021)
→ S. Mauthe, et al., Nano Letters 20(12), 2020
→ M. Scherrer, et al., Applied Sciences 11(4), 2021